High Performance Computing is key to addressing the DoD's most significant challenges

Computational Research for Engineering and Science Ground Vehicle (CRES-GV)

Computational Research for Engineering and Science Ground Vehicles

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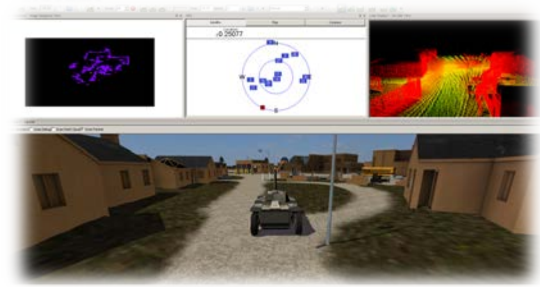
Agenda

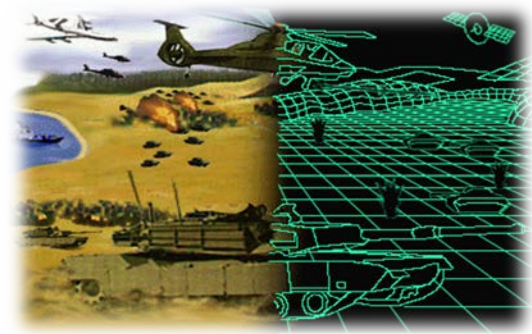
- HPC is the Key
- Acquisition driving needs
- Preliminary product ideas
- Discussion items

High Performance Computing (HPC) is key to addressing the DoD's most significant challenges:

- In *research*, HPC enables exploration and evaluation of new theories well beyond what is financially possible using experiments alone.



- In *acquisition*, HPC facilitates the use of comprehensive multi-scale, physics-based, validated applications for requirements, specifications, acquisition, and testing of complex systems.



- In *operations*, HPC allows for real-time calculations to produce just-in-time information for decision makers on the battlefield.

HPC is transforming and revolutionizing DoD's ability to accomplish its present and future mission.

Computational Research for Engineering and Science - Ground Vehicle (CRES-GV)

- Develop an HPC software suite to perform physics-based systems integration of ground systems.
  - Supported, commercial quality
  - Government owned
- Acquisition program focus
  - Positively impact cost, schedule, performance and reduce risk
- Goal: OEM <u>and</u> government use

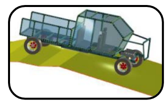
CRES-GV Focus

<u>HPC Solutions for;</u>

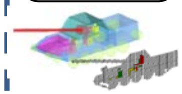
- Mixed-fidelity multidisciplinary physics solver
- Optimization tool focusing on robustness
- Supply of data to high level trade-space tools
- Improved Soldier–in-the-Loop using virtual systems
- Enhanced collaboration for design and analysis

How CRES-GV Solver Will Integrate

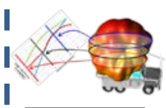
CRES Multiphysics Quick Turnaround HPC-Enabled Solver Suite



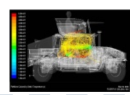
- Propulsion
- Mobility & vehicle dynamics
- Stress / fatigue



- Survivability (energetic effects, penetration, shotlining)



- Antenna and sensor placement



- Thermal/ fluids

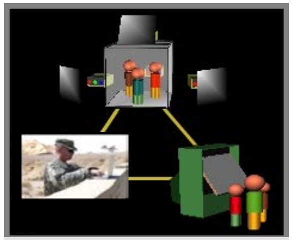
Feeds Existing Operational Models

- Better vehicle data = better results
- Improved vehicle requirements

Enhanced Soldier-In-The-Loop

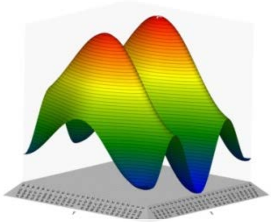
- Enables soldier-centric design
- Accurate geo-environments
- Duty cycle characterization

Immersive Collaboration Environment



- 3-d Immersive Collaboration
- Pre/post processing
- Better user feedback

Thorough Designspace Exploration



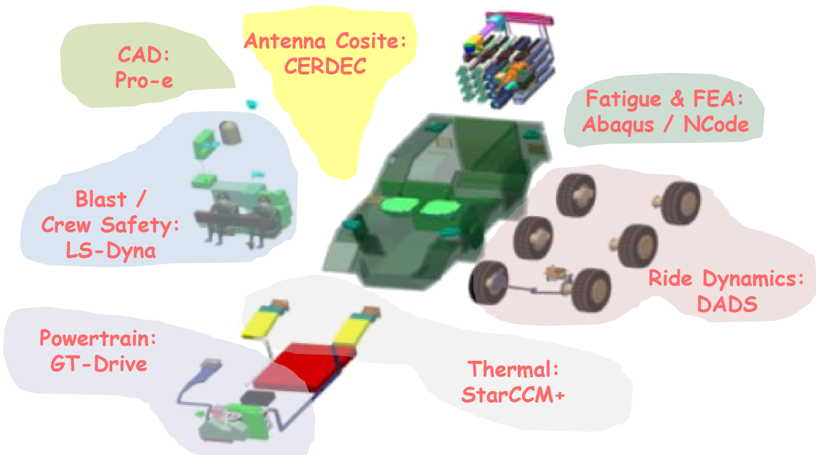
- Robustness optimization

- Allow interactive exploration of the requirements space

Why Should We Care? Systems Integration

Current Practice = Performance Risk

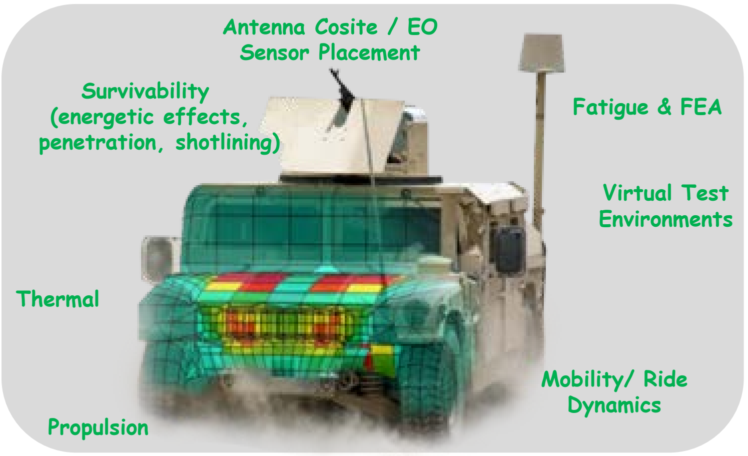
- “Stovepiped” analysis performed by separate SMEs in each physics domain = RISK



CRES-GV Approach = Reduced Risk

- Integrated analysis performed for all physics domains = REDUCED RISK
- Captures secondary effects

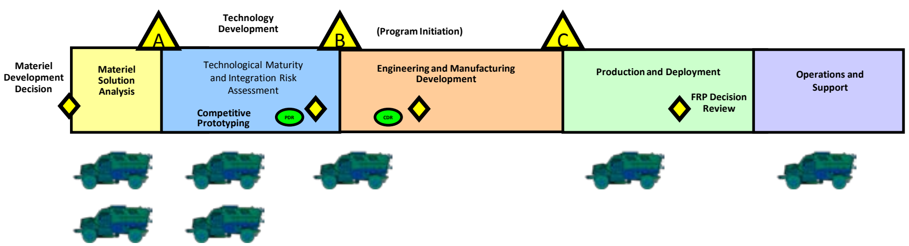
Virtual Systems Integration



Why Should We Care? Cycle Time

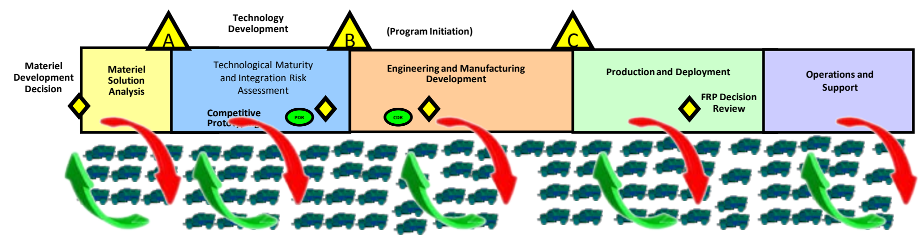
Current Practice = Schedule and Performance Risk

- 2-3 month turn around on CAE = Non optimized system and limited flexibility



CRES-GV Approach = Improved Schedule & Reduced Performance Risk

- 72 hour turn around on CAE = Maximum design flexibility and optimization
- More iterations better designspace explorations



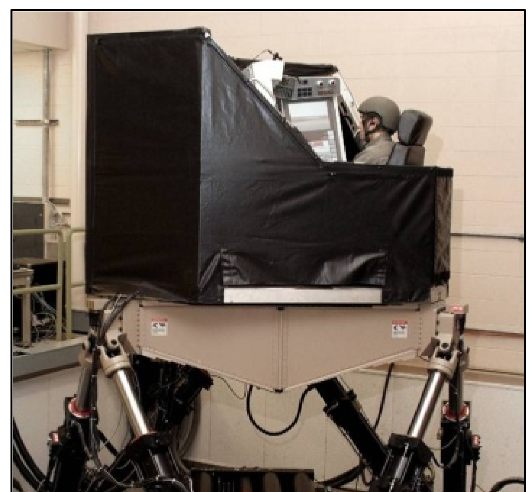
Why Should We Care? Soldier Centric Design

Current Practice = Performance risk, Schedule and cost risk

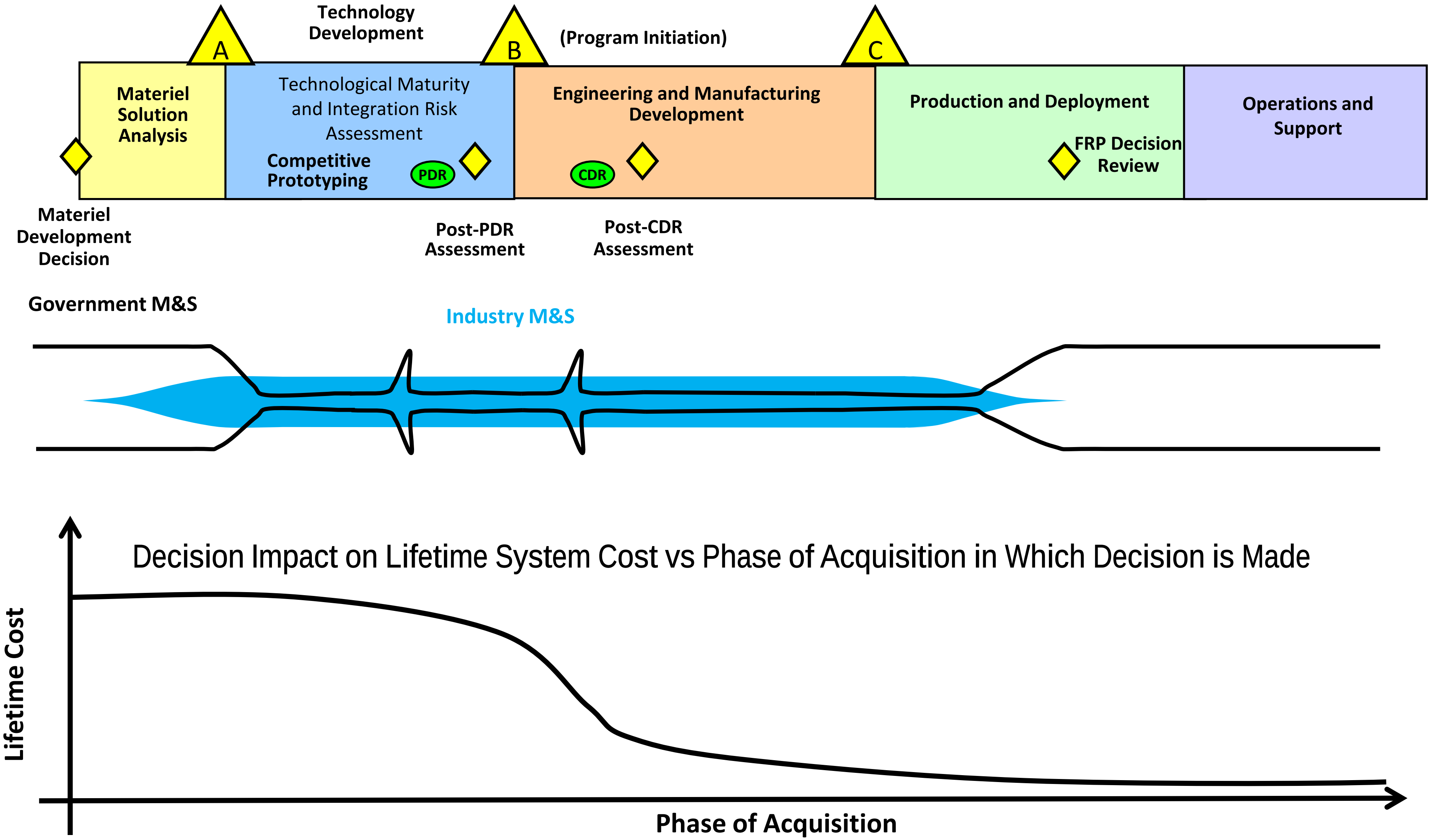
- Soldier only able to "kick tires" of physical prototype

CRES-GV Approach = Improved Performance Eliminates rework cost and schedule impacts

- Soldier able to try out virtual vehicle before metal is cut
- Ride quality / 360 degree awareness issues
- Layout of gauges and crew station
- Evaluate duty cycles



HPC Impact on Design and Acquisition



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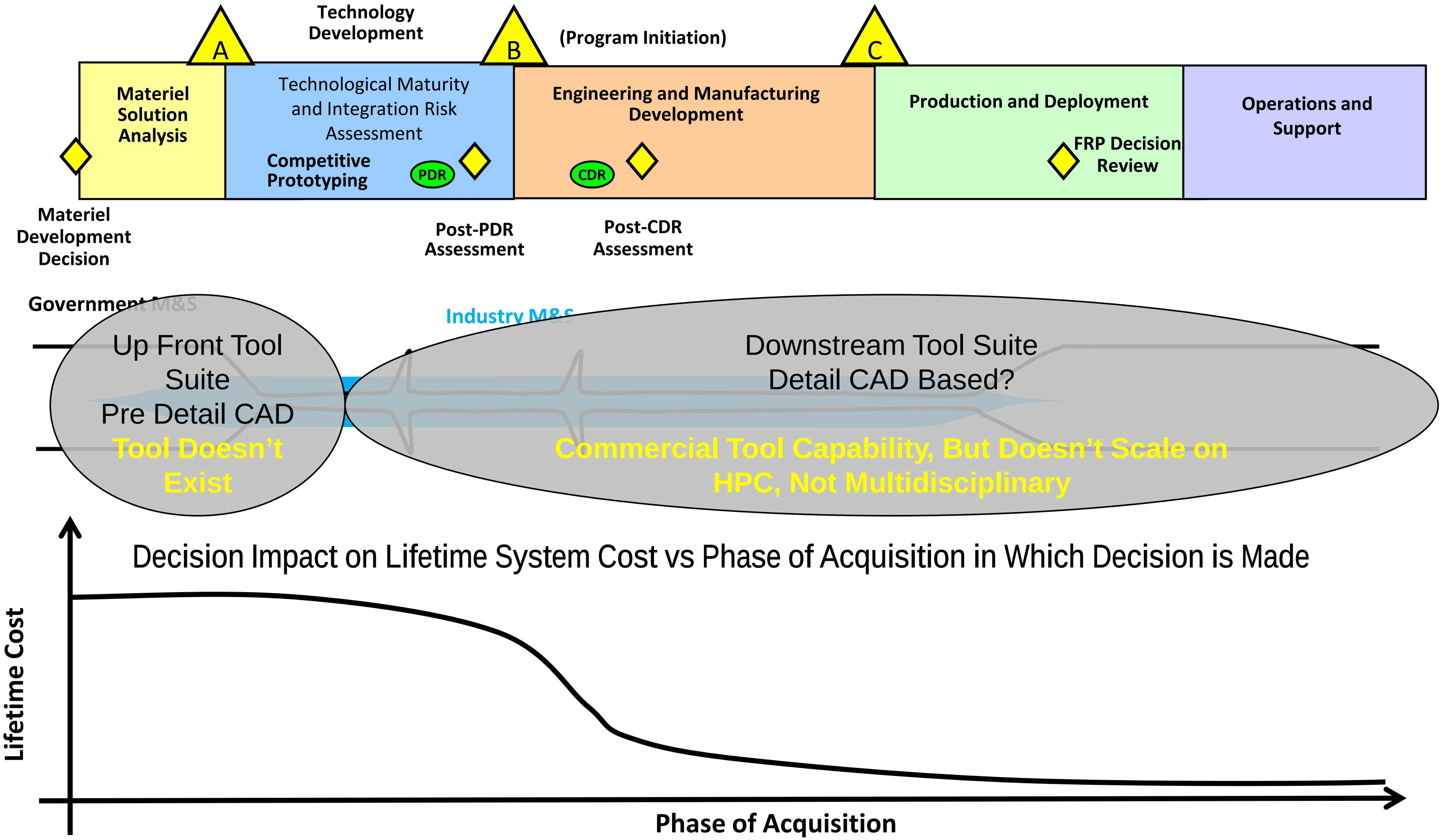
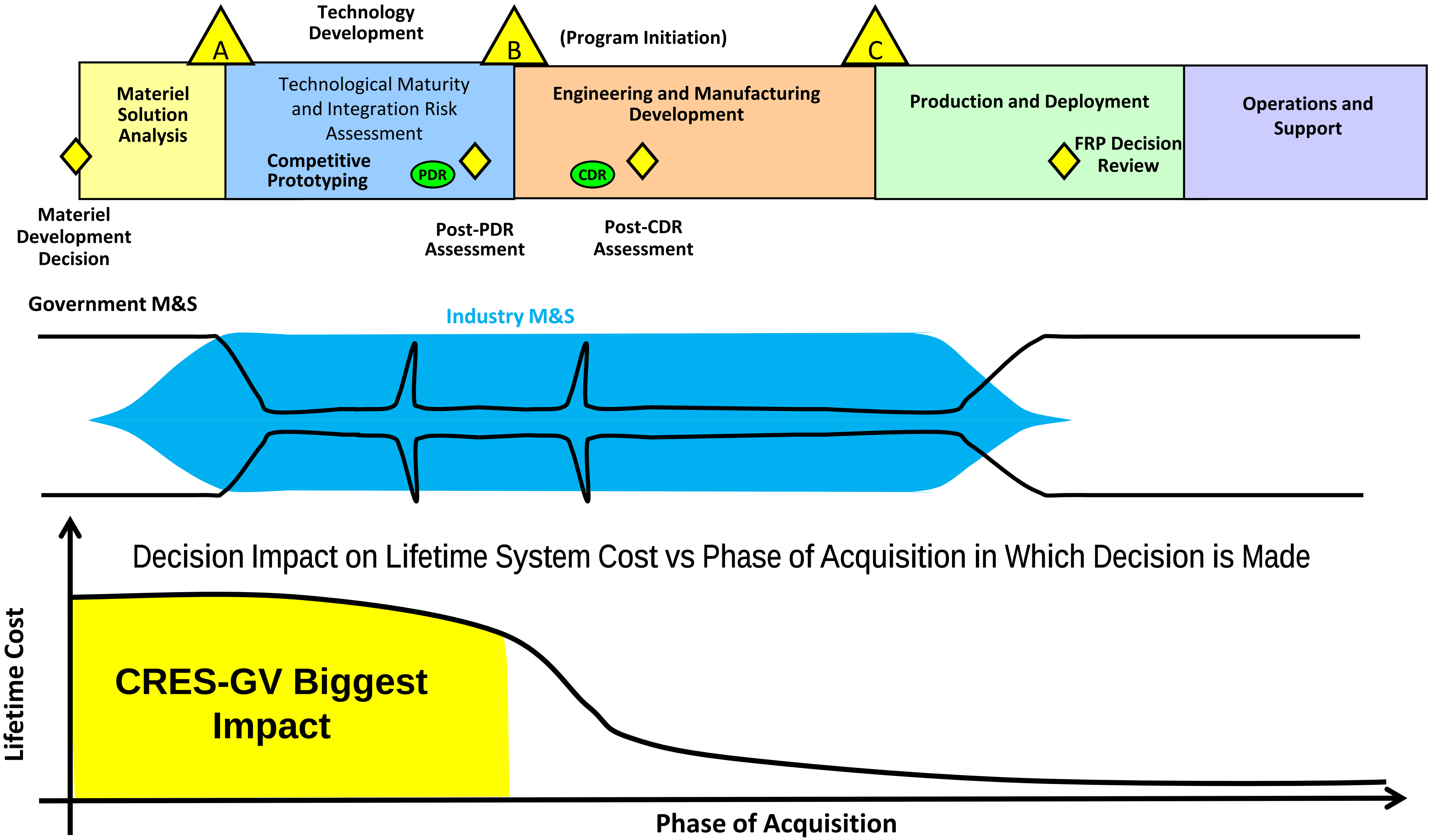
HPC Impact on Design and Acquisition



HPC Impact on Design and Acquisition



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Conclusions

- Develop an HPC software suite to perform physics-based systems integration of ground systems
  - Knowledge up-front and early
  - Supported, commercial quality
  - Government owned
- Acquisition program focus
  - Positively impact cost, schedule, performance and risk
- OEM <u>and</u> government use will enhance designs directly and not just requirements

BACKUP

Computational Research for Engineering and Science – Ground Vehicle (CRES-GV)

Objectives and Capability Payoff

Objective

- The objective is to develop validated physics-based modeling and simulation methods to assist in the design and development phase of ground vehicles. Modeling and simulation methods are critical in assessing the performance requirements of competing designs, and in conducting trade-off studies and sensitivity analyses or "what-if" scenarios to help in the development of a robust vehicle design which meets and/or exceeds all functional and performance requirements. The capability being developed can also be used to understand the performance of current vehicles in operational environments.

Capability payoff:

- HPC hardware capabilities, coupled with a focused development of physics-based software tools and the ease of use of these tools from the designers desktop will revolutionize the Ground Vehicle design and development acquisition process and the system life cycle costs.
- Program Executive Offices (PEOs) and Project/Product Managers (PMs) will be able to make informed decisions of new concepts for initial design or for modifications of existing systems based on sound fundamental science and engineering principals.

Funding, Schedule and Performers

- **Year 1:** Finalize working group, apply the methodologies for integration and full leveraging of the HPCMP CREATE project, requirements gathering from the analytical and end-user communities, identify existing and relevant computational tools, develop and strengthen partner relationships by identifying existing and potential commercial and industry partners, create a board of directors, and obtain endorsements from the acquisition community.

- **Year 2-3:** Execute program

ORG	FY-12 ($K)	FY-13 ($K)	TOTAL ($K)
ERDC	180	-	-
TARDEC	320	-	-
TOTAL	500	5000	5500

Technical challenge & approach

Technical Challenges:

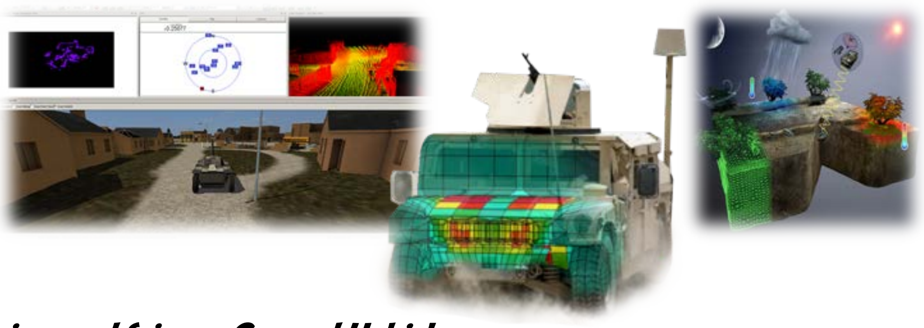
- Software tools that enable computational designs to use comprehensive multi-scale analysis methods.
- Integration of computational tools which include both the geo-environment and vehicle for assessing ground vehicle design and performance.

Technology / Approach:

- Multi-scale, physics-based modeling for ground vehicle designs based on physical characteristics and composition which would allow the computation of the projected performance for the alternative designs.
- "System of systems" approach for ground vehicle design, requiring a multi-disciplinary optimization process incorporating aspects of mobility, vehicle dynamics, energetic effects, propulsion, thermal, acoustic, and fluid effects.

Accomplishments & Transition (potential)

- HPC hardware capabilities, coupled with a focused development of physics-based software tools and the ease of use of these tools from the designers desktop, will revolutionize the Ground Vehicle design and development acquisition process, significantly reduce system life cycle costs, and shorten acquisition schedules. PEOs and PMs will be able to make informed decisions of new concepts for initial design or for modifications of existing systems based on sound fundamental science and engineering principals, enhanced by CRES-GV.



Technology Focus for HPC Multi-Scale, Physics-Based Modeling

- Propulsion
- Survivability (blast, penetration, shotlining)
- Thermal
- Antenna and sensor placement
- Duty cycles
- Mobility & vehicle dynamics
- Stress / fatigue